FORESTRY RESEARCH

WHAT'S NEW IN THE WEST   Sept. 1976

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a note to you

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on the cover

Dr. Richard "Skeeter" Werner of the Institute of Northern Forestry checks an insect trap near Fairbanks, Alaska (see story, page 1). *Inside:* page 6 photo courtesy John Schomaker; page 7 photo, upper right, (citizens' community planning group) courtesy Fort Collins *Coloradoan.*

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Alaska—filling in the gaps

Two men, working more than a thousand miles apart, are involved in some of the most exciting forestry research in Alaska. Richard "Skeeter" Werner of the Pacific Northwest Station's Institute of Northern Forestry in Fairbanks, and John Hard of the Station's Forestry Sciences Laboratory in Juneau, are research entomologists. Their work involves millions of acres of forests, populated with all of the unknowns that a scientist could want.

In many ways the world of the Alaskan forests remains an enigma. For example, Werner points out that in 1975, thousands of acres of larch were defoliated in Alaska's interior region, south of Fairbanks. The insect which caused the defoliation has not been identified.

Werner and his coworkers at the Institute of Northern Forestry are in a unique position to make significant contributions to knowledge of the forest ecosystem of interior Alaska. They are currently working on a series of studies about epidemics of the spear-marked black moth. During the past 2 years, this moth has raged throughout the interior, defoliating millions of acres of birch. The

▼ Forest Service researchers in Juneau are working on the insect problems of southeast Alaska.

damage has been so extensive that the brown and golden colors of the hard-hit trees make it appear that fall exists year round.

Werner points out that there have been periodic outbreaks of defoliators for as long as records have been kept and that these insects usually hit millions of acres because of the homogeneous nature of interior timber stands.

Research on the spear-marked black moth is progressing. So far, life history studies have identified four larval stages. The pupae develop in the forest duff and emerge as adults during June. A virus, two fungi, and a bacterium have been found to kill 80 to 90 percent of the third and fourth instar larval stages and parasites have killed up to 95 percent of the pupae. The identification of these agents holds promise for natural control methods. Werner and his colleagues at the Institute of Northern Forestry assume that birch and other hardwoods will become economically important in the future in interior Alaska, and for this reason are accelerating their research on the spear-marked black moth and other insects that attack hardwood trees.

Natural role of insects

Werner emphasizes the important natural role insects play in maintaining forest ecosystems. For instance, insects add to nutrient cycles. As they feed, leaf parts and waste drop to the forest floor by the ton, contributing to the slowly decomposing mass of the forest duff and the nutrient cycle. In addition, birds, yellow jackets, and hornets feed on the moths and act as natural controls.

Until recently the spruce bark beetle had received the most study in interior Alaska. Entomologists now feel that proper management of forests will reduce the destructive effects of this forest pest. They have found that the beetle populations expand in areas where untreated slash remains on the ground. Improving treatments of slash and other residues will significantly reduce the beetle problem.

The situation is different in southeast Alaska. There, the research emphasis is on the black-headed budworm and the hemlock sawfly. Between 1950 and 1955, the budworm was responsible for the defoliation of 9 to 10 million acres of Sitka spruce forest in southeast Alaska.

John Hard, entomologist with the Forestry Sciences Laboratory in Juneau, says that the focus of the budworm and sawfly research has been on the biology and population ecology of the two species. The most significant effect of both defoliators is reduction in the growth of affected trees, and some top kill. In several cases, all parts of the trees are killed.

Weather data analyzed

Hard points to several factors that help to control these forest pests. For example, the sawfly and budworm in southeast Alaska are living near the northern limit of their range, where conditions are less than ideal. Hard feels there may be a relationship between weather and insect outbreaks. He and Bill Farr, a research forester, are analyzing weather data from 50 to 60 stations in coastal Alaska. The weather data will be used to establish climatic zones to see how these zones compare with the areas where risk of insect attack is high.

The main research effort in southeast Alaska involves identification of natural controls and their interaction. Hard says that parasites and fungi, acting together with the cool, moist climate, usually control outbreaks naturally before damage becomes extensive in virgin stands.

Most Alaskan timber is harvested from the hemlock and Sitka spruce forests of the southeastern panhandle. The rate of timber harvest has increased since the 1950's. Any time an environment is modified, the risk of problems, such as insect outbreaks, is increased. Hard feels it is highly probable that chemical control will become more necessary as young, managed forests replace the old growth. Environmentally safe chemicals such as Orthene, Dylox, and Lannate have been tested and look promising.

The work of Werner, Hard, and other entomologists is filling the gaps in man's knowledge of the forest ecosystem of Alaska. These research results are helping to insure productive resource management for the Land of the Midnight Sun.

—By Thomas M. Baugh, Pacific Northwest Station

John Hard is now with the Pacific Southwest Station's Field Evaluation of Chemical Insecticides Unit in Davis, California.

Those beetles in the trees

The mountain pine beetle has probably always been present in the millions of acres of lodgepole pine forests in the West. One of the earliest infestations existed in the Horse Creek Drainage of Utah Territory more than 180 years ago, long before white men began to explore the Wasatch Mountains.

Infestations may not always be troublesome: when beetle numbers are relatively small, the quarter-inch long, black insect and the lodgepole trees coexist rather peacefully. But during a beetle population explosion, which can occur every 20 to 40 years in a given area, hordes of beetles can destroy entire forests.

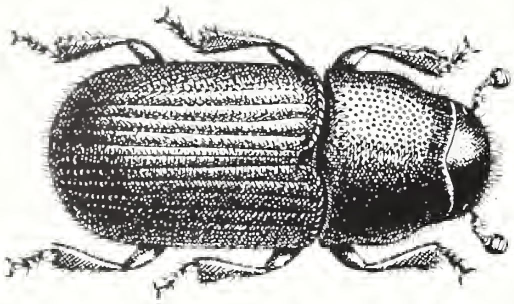
Scientists at the Intermountain Forest and Range Experiment Station, along with cooperators, have conducted extensive research to better understand the mountain pine beetle's life cycle and relationship to lodgepole pine. Now their emphasis is shifting to application of the research results to promote effective control of the beetle.

A major step in the control work is the development of a model that demonstrates the interaction of beetle populations with lodgepole stands. "We based our model on 14 years of data on population dynamics of bark beetles," explains Dr. Walter E. Cole, project leader in charge of the research. "Use of the model has already helped us prepare some preliminary management strategies to deal more effectively with the insect."

Attacking beetles leave telltale boring dust in bark crevices and on the ground at the base of a tree. A few weeks after entry, fungi carried by the beetles stain the wood blue just beneath the bark. This is a certain indication that the tree has been attacked and killed. When the tree is attacked, the color of the needles changes from healthy green to deep reddish-brown. The change is so gradual that it is usually not noticeable until the spring following attack. Needles drop off the tree within 2 or 3 years after the attack.

▼ Cage used for pine beetle study, Wasatch National Forest.

▼ Adult mountain pine beetle (enlarged).



Mountain pine beetles may attack individual, scattered trees, but more often they attack entire groups of trees. These group infestations can expand with each new beetle generation, and eventually, large areas may suffer extreme losses of forest cover.

Intermountain Station studies indicate that few lodgepole pine stands in the Intermountain and Northern Rocky Mountain areas are safe from the beetle. Depending upon the characteristics of sites, from 44 to 90 percent of lodgepole stands have experienced or will experience an epidemic. Usually, an epidemic lasts from 6 to 8 years. Once an infestation has reached epidemic proportions there's nothing anyone can do to stop it, Cole says.

The beetle at work

Natural enemies of the beetle—woodpeckers and several insects—become more numerous when beetle populations are high. However, these natural predators do not provide effective control by themselves.

Unfortunately, the beetles attack the most healthy, vigorous trees in a lodgepole stand. Because beetles prefer larger diameter trees, losses range from 1 percent of 4-inch diameter lodgepole to 87 percent of trees with 16-inch or larger diameters. In some stands, all trees over 12 inches in diameter are killed.

When adult beetles seek new, green trees to infest, they seem to search for large, dark objects against a light background. This searching behavior helps beetle populations expand, simply because the larger trees provide the greatest food supply.

The flight period lasts from late summer to early fall. Mating occurs after the female bores into the trees. Small grubs hatch from eggs and begin to feed on the tree's phloem tissue before hibernating for the winter. Phloem is a complex layer of living tissue just beneath the bark through which ingredients of a tree's food supply are transmitted.

In spring, the grubs resume feeding and grow into pupae. By midsummer, new adults emerge from the now-dead tree and fly to living trees to launch a new 12-month beetle life cycle.

The Intermountain Station researchers have found that, in addition to the number and distribution of large diameter lodgepole, thickness of phloem tissue is very important to beetles. If the phloem is thicker than one-tenth inch, beetles can produce large numbers of eggs, and populations can expand to epidemic proportions. In thinner phloem, they do not thrive, and populations may decrease. In general, large diameter trees contain thick phloem; small diameter trees contain thin phloem.

No blanket prescription

The site and elevation of a stand of trees also are important. Beetle survival is much greater at lower elevation sites—beetles are less able to withstand the harsh environments of high elevations. Other factors—temperature, population density, and rate of phloem drying—also influence the amount of loss caused by a mountain pine beetle infestation.

According to Cole, there is no blanket prescription for management of infested lodgepole pine stands. "Clearcutting might be the best method of control in some areas, but is taboo where recreation or watershed values are high."

Cole recommends removing trees before they reach vulnerable sizes, thus eliminating or reducing the potential for beetle epidemics. Because beetle behavior is so closely tied to food supply—large diameter trees with thick phloem tissue—logging the proper trees in a stand would reduce the food supply before the beetle becomes excessively active within the stand.

An estimated 69 percent of all emerging adult beetles come from infested trees 12 inches or larger in diameter, and 89 percent of emerging adults come from trees with 10-inch or larger diameters.

Dr. Cole says, "We will have to be satisfied with harvesting smaller diameter trees. This will mean a 60-year rotation period instead of an 80- to 100-year rotation. If the food isn't there, the beetles won't be there. If we keep 5 years ahead of the beetle, by managing stands to limit the food supply, we have a good chance of winning."

Managing lodgepole pine in this manner also should provide a continuous supply of timber, forest cover for recreation and watershed purposes, and sound wildlife habitat.

Meeting the challenge

Although scientists have developed basic knowledge of beetle biology and several control techniques, there is a great need to integrate beetle control strategies into forest management practices. Existing techniques and knowledge must be perfected through experimental testing.

More scientific knowledge is needed of the relation between mountain pine beetle populations and forest stand dynamics to refine trend predictions and to more fully understand mechanisms that trigger epidemics. This research should emphasize study of diseases—root rot and dwarf mistletoe—and other insects that may set the stage for beetle attacks.

Additional research also is needed to evaluate alternative methods of beetle control. Possibilities include chemical attractants, repellants, and protective substances, and effective methods to apply them to tree stands without impairing forest values.

Expanding knowledge of the mountain pine beetle, plus expanding markets for lodgepole pine harvested in prevention programs, will help contain the tiny black beetles and assure a continuing supply of green trees in the Rocky Mountains.

If you would like to know more about Intermountain Station studies of the mountain pine beetle, Dr. Cole recommends the following publications: "Mountain Pine Beetle Brood Production in Relation to Thickness of Lodgepole Pine Phloem," by Gene D. Amman, *Journal of Economic Entomology* 65(1):138-140; "Mountain Pine Beetle Influence on Lodgepole Pine Stand Structure," by Gene D. Amman and Bruce H. Baker, *Journal of Forestry* 70(4):204-209; "Population Changes of the Mountain Pine Beetle in Relation to Elevation," by Gene D. Amman, *Environmental Entomology* 2(4):541-547; "Interaction Between Mountain Pine Beetle and Dynamics of Lodgepole Pine Stands," by Walter E. Cole, Research Note INT-170-FR7; "Competing Risks Analysis in Mountain Pine Beetle Dynamics," by Walter E. Cole, *Researches on Population Ecology* 15(2):183-192; "Interpreting Some Mortality Factor Interactions Within Mountain Pine Beetle Broods," by Walter E. Cole, *Environmental Entomology* 4(1):97-102; "Flight and Attack Behavior of Mountain Pine Beetles in Lodgepole Pine of Northern Utah and Southern Idaho," by Lynn A. Rasmussen, Research Note INT-180-FR7; and "Mathematical Models for the Mountain Pine Beetle–Lodgepole Pine Interaction," by Walter E. Cole, Gene D. Amman, and Chester E. Jensen, *Environmental Entomology* 5(1):11-19.

—By Dick Klade, Intermountain Station

▼ Lodgepole pine devastated by the mountain pine beetle.

▲ What experiences and benefits do recreationists gain from specific activities?

Recreation—for what benefits?

Why do people engage in various outdoor recreation activities? What benefits do they gain? How can knowledge of these benefits help land managers decide what or what not to do? Dr. B. L. Driver, project leader for recreation research at the Rocky Mountain Station, Fort Collins, Colorado, is seeking answers to these questions. The objective of the program Driver directs is to identify and measure the benefits recreationists receive from specific types of outdoor activities and environments. He believes this information will help land managers compare recreation values with other resource values in an efficient and equitable manner.

The research at Rocky Mountain Station is part of a much broader recreation program involving most Forest Service Experiment Stations. In the West, Driver coordinates his work with that of Gary Elsner, Pacific Southwest Station; John Hendee, Pacific Northwest Station; and Bob Lucas, Intermountain Station. Elsner and his associates are developing computerized systems for processing recreation planning information, particularly in the field of visual landscape management (see *Forestry Research*, February 1975, p. 6). John Hendee and his colleagues are obtaining information on dispersed recreation in areas other than wilderness, particularly recreation associated with consumptive (hunting) and non-consumptive uses of wildlife. They are also looking for ways to reduce vandalism, littering (see *Forestry Research*, December 1975, p. 7), and other types of undesirable behavior. Bob Lucas is directing studies on wilderness management (see *Forestry Research*, April 1976, p. 11). These scientists are seeking ways to improve the recreation environment.

Driver wants to know how the recreationist "profits" from these improvements and from other conditions and circumstances surrounding recreation pursuits.

In most areas of resource management—timber, watershed, wildlife, or range—it is not too difficult to identify and quantify products in specific terms. Recreation, however, is an exception—it is quite difficult to define the social goods and services produced. What are the benefits realized from a forest campground, for example? Are they camping opportunities, such as 90 sites per day for 120 days per year? Are they "X" number of visitors or "Y" number of visitor days? Are they "Z" units of user satisfaction? Are they human beings who are better able to cope with personal and social problems as a result of their outdoor experiences? Are the goods and services produced all of these, and more? How can these products be compared with benefits resulting from alternative resource uses, such as the production of "X" board feet of lumber?

In the past, many management decisions related to recreation have been based on intuition. However, untested intuition can lead to biased appraisals of the products we suppose result from outdoor recreation activities. For this reason, Driver is working to develop objective measures of the goods and services resulting from outdoor recreation. His first task has been to separate the

▲ Is a person a better citizen after outdoor recreation?

demands of recreationists into four categories:

1. Demands for recreation activity opportunities, such as the opportunity to hunt elk, to camp in a wilderness area, or to canoe whitewater.

2. Demands for specific resource attributes, social settings, or management actions that help users have specific satisfying experiences. These "attribute demands" include such things as trophy elk, untrammeled wilderness, fast whitewater, low levels of congestion and noise, or reasonable entrance prices.

3. Demands for specific basic experiences that give satisfaction. Examples are skill testing, exploration, esthetic enjoyment, family togetherness, mental relaxation, privacy, social recognition, exercise, or nature learning.

4. Demands for the physiological, psychological, and sociological benefits resulting from basic experiences. These benefits, defined in terms of improved performances when the recreationists go back home, include improved physical and mental health, enhanced self-confidence, improved job performance, increased family solidarity, or greater commitment to resource conservation.

◀ Can city recreation substitute for other activities?

Recreationists are more aware of their demands for specific activities and the conditions surrounding those activities (1 and 2 above) than they are of the basic experiences or benefits (3 and 4). However, Driver sees categories 3 and 4—those satisfying experiences and positive personal and social changes resulting from participation in outdoor recreation activities—as the ultimate goods and services produced.

The research Driver supervises is based on this demand scheme and is proceeding in two phases. In phase one, questionnaires are being designed to quantify the relative importance of more than 40 types of desired and expected recreation experiences. Using these questionnaires, researchers are identifying experiences which are in most demand and the importance of each experience to participants in specific activities.

Second phase studies

Results so far show that users engage in particular activities to realize several satisfying experiences. Some of these experiences are more highly valued than others. For this reason, a particular activity is chosen so that the user might gain the most valued types of experiences afforded by that activity. The results also show that some experiences, such as solitude, risk-taking, skill development, and family togetherness, are highly dependent on specific characteristics of the physical and social setting where the activity takes place. Conditions at home and work seem to influence the types of experiences expected, too.

Information gained on user preferences will by itself be useful to management. Also, it will be the basis of the second phase studies. In this phase, the "experience demands" of clearly defined user groups will be used to formulate hypotheses about possible benefits for various types of users. These hypotheses will then be tested to identify and quantify specific benefits.

Cooperators such as Dr. Perry Brown of Colorado State University and Dr. George Peterson of Northwestern University, member institutions of the Eisenhower Consortium for Western Environmental Forestry Research, and other Forest Service research units are making major contributions to the Rocky Mountain Station recreation research program. The results of this work should give planners, managers, and policymakers better information to answer such questions as: What types of recreation opportunities should be provided? Where? When? By whom? For whom? At what price? What substitute opportunities can be provided and still produce desired experiences and benefits? How willing are recreationists to pay, or to commit other personal resources, to achieve desired experiences? Can the needed natural resources be committed to make possible the experiences and benefits unique to a given environment?

For more information about this research, write or call Dr. Driver at the Rocky Mountain Station (303) 482-7332; on FTS phone 323-5211. Several recent publications on this type of research are listed below. Copies may be obtained from the sources named in the citations:

Driver, B. L. 1976. Quantification of Outdoor Recreationists' Preferences. *In* Research, Camping and Environmental Education. p. 165-187. Betty van der Smissen and Judy Myers, eds. Penn State Univ., HPER Series No. 11.

Driver, B. L. 1976. Toward a Better Understanding of the Social Benefits of Outdoor Recreation Participation. *In* Proceedings Southern States Recreation Research Applications Workshop. p. 163-189. USDA Forest Serv. Gen. Tech. Rep. SE-9. Southeastern Forest Exp. Stn., Asheville, N.C.

Driver, B. L., and John R. Bassett. 1975. Defining Conflicts Among River Users: A Case Study of Michigan's AuSable River. *Naturalist* 26(1):19-23.

Driver, B. L., and Perry J. Brown. 1975. A Social-psychological Definition of Recreation Demand, with Implications for Recreation Resource Planning. *In* Assessing Demand for Outdoor Recreation. Appendix A, p. 63-88. Natl. Acad. Sci., Wash., D.C.

Driver, B. L., and S. R. Tocher. 1970. Toward a Behavioral Interpretation of Recreation, With Implications for Planning. *In* Elements of Outdoor Recreation Planning. p. 9-31. B. L. Driver, ed. Univ. Mich. Press, Ann Arbor.

Knopf, Richard C., B. L. Driver, and John R. Bassett. 1973. Motivations for Fishing. *In* Transactions of the 38th North American Wildlife and Natural Resources Conference. p. 191-204. Wildlife Manage. Inst., Wash., D.C.

—By Phil Johnson, Rocky Mountain Station

Pheromones for insect control

The Douglas-fir tussock moth is still making history in the Pacific Northwest, but more quietly now than during the most recent—and most severe—of its periodic outbreaks. Between 1970 and 1974 the population of this permanent resident of Northwest forests increased so rapidly that it severely defoliated portions of forests in Oregon, Washington, and Idaho.

In 1976, the search continues for better ways to cope with future outbreaks. One of the most promising new control techniques may be the pheromone or sex attractant of the tussock moth, produced artificially in the laboratory in 1974. Development of the artificial sex attractant, which duplicates the natural attractant of the moth, may soon make it possible to determine the location and size of local populations. Eventually the attractant may also be developed as a control technique.

The scientific team that identified and synthesized the pheromone is headed by Dr. Gary Daterman, an entomologist at the Pacific Northwest Station's Forestry Sciences Laboratory in Corvallis, and Dr. Doyle Daves and Dr. Ronald Smith, chemists at the Oregon Graduate Center, Beaverton. Supporting and assisting them are technicians who perform highly specialized tasks. Dr. Lonne Sower, a recent transfer from the Agricultural Research Service, is an experienced pheromone scientist who has joined this team to assist in development of pheromones of tussock moths and other insects.

In 1973, the same team identified the sex attractant of the pine shoot moth. Using similar

▼ Female Douglas-fir tussock moth pupae contain eggs and are larger than the male pupae.

laboratory and field procedures, they are now working to identify the attractants of the western tussock moth and the rusty tussock moth. Though these insects are far less destructive to Northwest conifers than the Douglas-fir tussock moth, scientists are interested in their attractants because these moths are closely related. In the woods they may even be attracted by the same pheromone.

In their collaboration, which began in 1970, Daterman, Daves, and Smith have developed their own investigative methods for tuning in on insect communication. It is a process that requires perseverance, and, most of all, cooperation between the chemist and the entomologist.

The first step is to find out whether the insect has an attractant and, if so, which sex produces it. To start with, the entomologist grinds up the abdomens of female insects and mixes them in a solution, which is filtered and tested on male moths. The solution will contain hundreds of compounds, such as fats, waxes, and sugars, but if the male responds, it also contains an attractant. The problem now becomes the task of identifying this seductive pheromone so that it can be isolated from the other chemicals.

Separating the compounds

The purification process is a sort of laboratory do-si-do in which the entomological and chemical teams take turns performing their specialized procedures. The chemist's job is to eliminate all compounds except the pheromone. The entomologist's job is to test the material on male moths to verify attractiveness of test samples.

The chemists use column and gas chromatography and mass spectrometry to separate the various compounds and to divide the solution into small fractions. The entomologist tests each fraction on male moths in a laboratory cage. The fractions that attract moths are separated further; these fractions are again tested on male moths. This process may be repeated dozens of times until only the attractive chemical remains.

Finally, the chemists are able to make a substance identical to the one female moths produce so effortlessly. The chemical that attracts the Douglas-fir tussock moth is cis-6-heneicosen-11-one. It is highly attractive to male moths regardless of whether it comes from a female moth or a chemical laboratory. A one-anogram sample—35 trillionths of an ounce—is enough to attract male moths in laboratory tests.

In 1975, field studies to develop new control methods for the Douglas-fir tussock moth were carried out by Forest Service and cooperating researchers under an accelerated research program of the U.S. Department of Agriculture. Nine Western States and British Columbia were involved. All cooperators reported captures of moths in areas where they could not be detected by other methods. In addition to Douglas-fir tussock moth, three other species were attracted by the chemical. Methods have been worked out to distinguish the different species captured in the cages.

A trapping procedure

In addition to conducting the pheromone studies, researchers are trying to develop an effective trapping procedure. The scientists have tested trap design, trap placement, the number of traps needed in an area, and the attractant dosage needed. The goal is to determine the relationship between the number of moths trapped and the total number of moths in a given area. When applied over a wide area, a trapping system could pinpoint areas where populations are increasing and require intensive surveillance. This information would help land managers forecast potential epidemics and make decisions about the need, timing, and methods for control.

The possibility that the sex attractant may be used for direct control is also under study. One way to do this may be to disrupt the reproductive behavior of the moth by permeating the atmosphere with the attractant so male moths cannot find the females. This approach has already been used successfully in field experiments against the gypsy moth and some agricultural pests.

Like most insects, the Douglas-fir tussock moth operates by instinct and reacts to behavioral stimuli. Once a stimulus such as the pheromone has been duplicated it can be used to manipulate or disrupt the normal life processes of an insect. The use of pheromones is particularly promising because only small quantities are needed, and because apparently there is no hazard to other parts of the environment.

—*By Dorothy Bergstrom, Pacific Northwest Station*

Imagery may aid wildland inventory

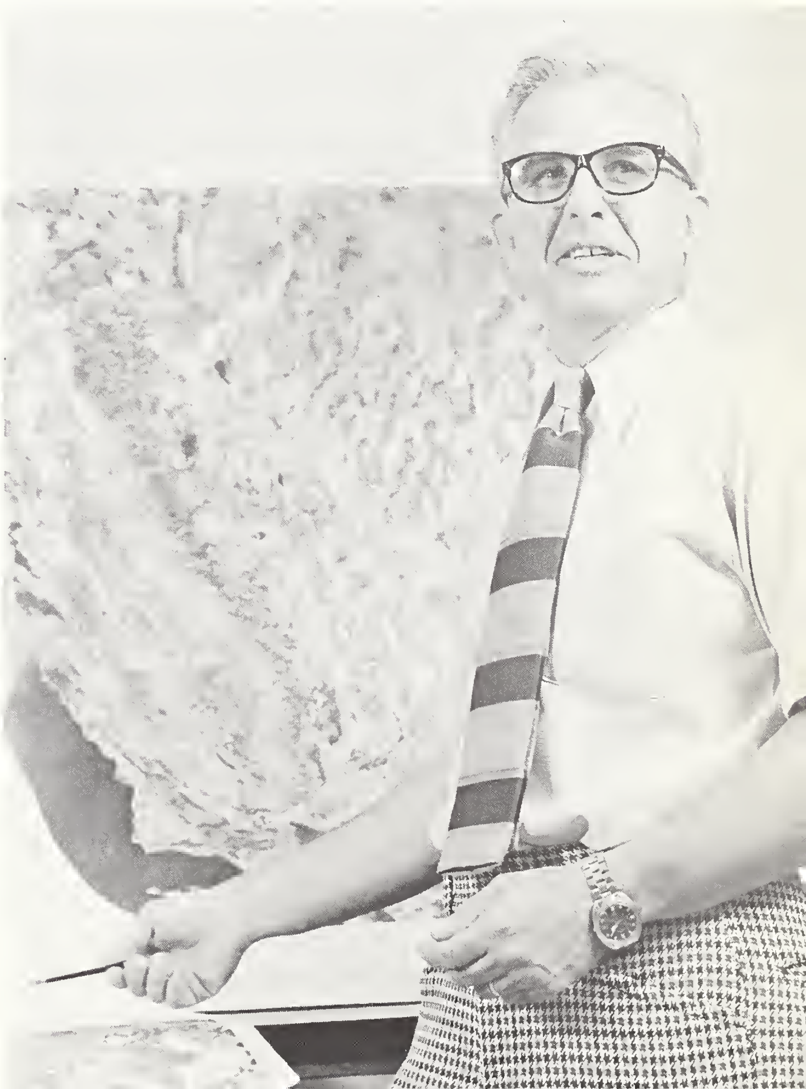
The cameras and scanners that were carried high above the earth in the ERTS-1 mission of 1972 and the Skylab maneuvers of 1973 provided photos and photo-like imagery of the earth's surface. Among the people who were anxious to get a look at this new imagery were scientists in the remote sensing research unit at the Pacific Southwest Station, Berkeley, California, and members of the range inventory staff at the Rocky Mountain Station, Fort Collins, Colorado. Both groups wanted to see if the imagery—taken from an altitude of 570 miles in the case of ERTS-1 and from 260 miles in Skylab—could provide faster and more accurate inventories of the nation's forests and rangelands—inventories that are vital if wildland managers are to have the up-to-date information they need in order to make resource decisions.

The scientists were concerned not only with exploring the uses of the imagery they had at hand, but also with reporting back to the National Aeronautics and Space Administration on possible ways to modify future flights, to produce better imagery for foresters and range managers.

The researchers found that although there are problems with the space data, and some limits to its use, much of it contains needed information on the location, size, and composition of forests and rangelands.

In the ERTS experiments, results indicate that, for now, the best use of this imagery is in distinguishing only the most general land-use classes. The ERTS data were gathered by multispectral scanner, a device that operates on the principle that each feature in the natural landscape absorbs, transmits, emits, and reflects a certain amount of radiation. These spectral properties give natural features distinctive, multispectral signatures. The ERTS multispectral scanner looks at approximately 1 acre of land at a time, measuring reflected energy in four spectral bands of the visible and near infrared portions of the electromagnetic spectrum. This radiance information was transmitted to ground stations, and recorded on magnetic tapes. The data were analyzed later to determine the location and components of all the scenes that were noted by the scanner. The analysis can be performed by computers that are specially programmed to translate the information. Or, the data can be reconstituted into photo-like, black-and-white or color composite imagery, which lacks the resolution of conventional aerial photography

▼ R. C. Aldrich was coordinator of the Skylab report.



but covers a much larger area than that shown in the standard aerial photo.

Test sites in the ERTS experiment included some of the countryside near Atlanta, Georgia, where forests—which comprise 60 percent of the study area—occur in a challenging checkerboard of small ownerships, interspersed with fields of crops and bodies of water. Other test sites included the Manitou Experimental Range in central Colorado, a mountainous area with a complex vegetational mosaic of forest and grassland types. Also included was a study area in the Black Hills of South Dakota, where the intent was to see if ERTS imagery could be used to detect infestations of the mountain pine beetle in ponderosa pine forests.

Data from the Atlanta site were useful only to the extent of classifying what was or was not forest. Neither the computer-assisted analyses of the magnetic tapes nor examinations of the photo-like imagery by skilled photointerpreters could detect, with the 95 percent accuracy required, whether areas identified as forests were pine or hardwood.

Imagery from other sites

In the Colorado study, examination of ERTS data by computer-assisted analysis of the magnetic tapes, by microdensitometer (an instrument that measures the density of the photo-like imagery for later separation, by computer, into different cover types), and by photointerpreters, were accurate enough in distinguishing deciduous forests from coniferous forests and grassland. But all approaches had too many errors in the next refinement—that of identifying the specific type of forest or grassland. The same was true with the Black Hills experiments—the space imagery could not be used beyond broad, general classifications. The attempt to identify forest trees under stress from mountain pine beetle attack was unsuccessful. Part of the problem was that the photointerpreters only had ERTS imagery from August and September of 1972, and needed—but didn't have—ERTS imagery for the same period for the following year, to use as an aid in detecting changes in the vegetation. Instead, the 1973 imagery was from June, "the worst possible time of the year to detect insect stress," because recent kills were barely beginning to show foliage discoloration.

A more detailed explanation of each of these studies and of related tests is included in "Evaluation of ERTS-1 Data for Forest and Rangeland Surveys," issued as Research Paper PSW-112-FR7. Copies are available from the Pacific Southwest Station, Berkeley.

Skylab results

The study of Skylab imagery was based on data obtained by a multispectral camera, a 13-channel multispectral scanner, and a terrain mapping camera carried on board the spacecraft. As with the ERTS study, the analyses of Skylab data—by photointerpreters, or by microdensitometer or computer—all met the accepted standard of accuracy in distinguishing forest from non-forest, and for identifying general rangeland classes, but could not be extended further into more detailed classifications. The Skylab and ERTS results did differ, however, in the mountain pine beetle study. Color photos from the Skylab mapping camera showed trees under stress, if they occurred in clusters that were at least 85 feet in length.

Some problems were similar to those that occurred in the ERTS study. One mistake in the interpretation of these photos, for example, was in incorrectly labeling wet meadows as mountain bunchgrass, an error that the researchers thought could probably be explained by the fact that the two types of vegetation intermingle as the meadows give way to mountain slopes. More information on the Skylab experiments is presented in "Evaluation of Skylab (EREP) Data for Forest and Rangeland Surveys," Research Paper PSW-113-FR7, which will be issued later this year by the Pacific Southwest Station.

—By Marcia Wood, Pacific Southwest Station

The Rocky Mountain and PSW Station units involved in the satellite experiments are now part of the new Resources Evaluation Techniques Research and Development Program. The group is responsible for developing a system for inventorying timber supplies, rangelands, recreation resources, and fish and wildlife habitat. These inventories are needed for estimating both current and future supplies. The Program is headquartered at the Rocky Mountain Station, Fort Collins.

Publications

▲ A productive range that once was chaparral land.

Rocky Mountain ranges

Grazing by domestic livestock or by wild game converts forage—a resource that could not otherwise be used—into needed food and fiber. In recent years, rangelands have been recognized for other resource values, such as water yield, esthetics, and recreation opportunities. Production of range-fed livestock once played a major role in the development of our nation. Continued use of range resources may well be important to our future welfare, because the amount of energy used to produce food via range grazing is well below the levels needed to grow food on cultivated lands.

Range scientists at the Rocky Mountain Station have published "status of knowledge" papers for seven range ecosystems in the central and southern Rockies. These papers synthesize 70 years of research and management experience. Each carries a description of (1) the resource, (2) effective range management techniques for the ecosystem, (3) ways to improve the forage resource, and (4) needs for additional information to cope with emerging problems.

Shrub and woodland ecosystems

S. Clark Martin of Tucson, Arizona, authored "Ecology and Management of Southwestern Semidesert Grass-Shrub Ranges" (Research Paper RM-156-FR7). This ecosystem encompasses a discontinuous belt 50 to 100 miles wide across valleys and lower mountain slopes between 3,000 and 5,000 feet elevation in southern Arizona, New Mexico, and west Texas. Livestock management systems here are designed to take advantage of forage growth following summer rains. Overgrazing encourages shrub invasion, particularly mesquite, which is difficult to get rid of. Yearlong grazing is common, but variations of rest, deferred, and rotation systems are proving effective. Martin notes the need for ways to integrate grazing with demands for desert recreation, wildlife habitat, and subdivision development.

Dwight R. Cable, also of Tucson, compiled "Range Management in the Chaparral Type and Its Ecological Basis" (Research Paper RM-155-FR7). This Southwest ecosystem is confined primarily to a narrow band of rugged country 3,000 to 6,000 feet in elevation south of Arizona's Mogollon Rim. Overgrazing near the turn of the century resulted in the dense brush stands that are present today. However, combinations of prescribed fire, mechanical removal, chemical reduction, and planned grazing can hold the chaparral in check while improving range conditions, wildlife habitat, water yield, and esthetics. Information is needed on grazing systems that incorporate chaparral control, improve grass production, and utilize nutritious shrub sprouts.

"Characteristics and Management of Southwestern Pinyon-Juniper Ranges" (Re-

search Paper RM-160-FR7) was authored by H. W. Springfield (now retired) of Albuquerque, New Mexico. Springfield notes this ecosystem occurs under diverse soils and climates between 4,500 and 7,500 feet elevation throughout the Southwest. Overgrazing, dating back 200 years in some cases, favored the dense woodlands found today in many grassland areas. Control of the pinyon-juniper, primarily by mechanical means, can restore grazing capacity, and can improve wildlife habitat and esthetics, if properly planned. Various forms of rotation and deferred grazing systems are proving more successful than season or yearlong systems. Seeding of depleted areas following control of the woody species can also yield excellent results if seedbeds are properly prepared and if steps are taken to conserve soil moisture.

Pine-bunchgrass ecosystems

Pat O. Currie, stationed at Fort Collins, Colorado, wrote "Grazing Management of Ponderosa Pine-Bunchgrass Ranges of the Central Rockies" (Research Paper RM-159-FR7). The ecosystem described occupies a band along either side of the Continental Divide from central Wyoming to central New Mexico at elevations of 5,000 to 9,500 feet. Forage is found in parks and meadows as well as in open pine stands. Overgrazing and abandoned farmsteads created severe watershed problems following World War I. Today, grazing management has restored range productivity, and reseeding has been highly successful, with the proper mix of species. Grazing seasons may be extended to 10 months, using the right combinations of seeded and native ranges. Intense pressures for recreation experiences and mountain home developments are being imposed on the ecosystem by nearby metropolitan areas. Current research is focusing on ways to integrate grazing and other resource demands into a complementary land management system.

"Range Management and Its Ecological Basis in the Ponderosa Pine Type of Arizona" (Research Paper RM-158-FR7) by Warren P. Clary, formerly of Flagstaff, Arizona, describes pine-bunchgrass lands between 6,000 and 9,000 feet elevation in the central part of that State. Since the early 1900's changes—from open forests to dense thickets of young trees—have been in part the result of protection from fire. Forage for livestock and big game has declined. Research has shown intensive silviculture can improve timber production and water yield from these forests, while enhancing forage for livestock and big game animals. Reseeding can also improve forage production. But, where reforestation is desired, reseeding should be limited to short-lived grasses and forbs. As with the pine type in the central Rockies, research here is focusing on ways to integrate rapidly growing recreation uses with other demands on range and associated resources.

▼ Cattle thrive on a seeded range in Colorado.

High mountain ecosystems

George C. Turner (now retired) of Fort Collins compiled information on "Management of Mountain Grassland" (Research Paper RM-161-FR7). Mountain grassland ranges comprise about 10 percent of the subalpine forest area between 8,000 and 11,500 feet elevation in Wyoming, Colorado, New Mexico, and Arizona. Though small in acreage, this range can be very productive. Local livestock producers rely on it for summer forage. Depending on the size of the ranching operation, season-long grazing at light stocking levels, or some form of deferred, rotation, or rest grazing system at more intense stocking levels, can be successfully applied. Overgrazing results in takeover by unpalatable weed species. More needs to be learned about basic vegetation-soil-site relationships and about integration of grazing with emerging recreation activities.

"Alpine Range Management in the Western United States—Principles, Practices, and Problems" (Research Paper RM-157-FR7) by John F. Thilenius of Laramie, Wyoming, summarizes the "status-of-our-knowledge" for the high ranges, from timberline to mountain top, stretching from northern Montana to northern New Mexico. Sheep are the primary domestic livestock users of these ranges. A variety of grazing techniques can be successfully applied under the direction of competent herders. However, under certain conditions, grazing with unherded bands of sheep may be as successful as herded management.

Because of the severity of the environment, reseeding and other improved practices have been only partially successful in rehabilitating damaged ranges. More precise ecological classification for alpine ranges is needed to improve the ability of managers to accommodate sheep and wildlife grazing, as well as back country recreation in this fragile environment.

Range ecosystems summary

Specialists in range management and related fields will find the detailed information and literature sources of these individual reports helpful to them as they seek solutions to range problems. Key facts from each "status-of-our-knowledge" paper are included in "Range Management in the Central and Southern Rocky Mountains—A Summary of the Status of Our Knowledge by Range Ecosystems" (Research Paper RM-154-FR7). Author Harold A. Paulsen, Jr., designed this document to give administrators a quick reference to range ecosystems of the Rockies as well as to the problems that need more study. This summary report, and the individual reports, are available from the Rocky Mountain Station.

Clearcutting and wildlife

Large-scale clearcutting in ponderosa pine can inhibit use of the forest by wildlife, research indicates. Some studies by J. Edward Dealy of the Pacific Northwest Station have shed light on this problem. Dealy found that clearcutting increased forage as expected, but that wildlife did not use the areas as much as they had before, probably because most feeding sites were too far from suitable cover.

Dealy indicates that timber management practices might be improved if foresters first determine how far an animal must go into a timber stand to be hidden from view. This distance can then be used as the radius in designing cover patches.

If timber harvesting is done in strips, care should also be taken to prevent the development of "shooting lanes"—continuous strips of leave timber—by interrupting the strips at reasonable distances with openings.

Other recommendations include minimizing the open areas that can be seen from any one point in block-shaped clearcuts, and

using cattle to remove cured grass. This last recommendation will produce new grass growth for wildlife during the fall, spring, and summer months.

"Management of Lodgepole Pine Ecosystems for Range and Wildlife," by J. Edward Dealy, is reprinted from the proceedings of the Management of Lodgepole Pine Symposium. For copies write the PNW Station.

Quiet campgrounds

Recreational use of roadless areas is increasing. Resource managers are faced with the problem of designing campgrounds for larger numbers of people while maintaining a quality backcountry experience.

A Pacific Northwest Station study proposes guidelines for placement of campsites in roadless areas. According to the authors, their suggestions will help minimize the impact of noise from campers. Their research was based on four assumptions: (1) visitors to roadless areas seek solitude and isolation from those outside of their immediate group; (2) the impact of auditory and visual encounters between parties is especially great at campsites; (3) the distance that campground noise travels indicates the campsite spacing necessary to minimize impacts between groups; and (4) the spacing between campsites is most critical in the interior (as opposed to peripheral) portions of a roadless area.

The researchers recommend placing campsites laterally along streams and as close to swift water as is ecologically acceptable. Lakeshores and meadows are unacceptable campsite locations because they do not dampen sound. The authors recommend taking advantage of any natural features that deaden noise.

"Guidelines for Roadless Area Campsite Spacing to Minimize Impact of Human-Related Noises," General Technical Report PNW-35-FR7, by Tom Dailey and Dave Redman, is available from the PNW Station.

Analyzing logging systems

Working in cooperation with Forest Service researchers, two industrial engineers have developed a system to collect time and motion study data on logging operations.

David F. Gibson, professor, Montana State University; and John H. Rodenberg, now with Weyerhaeuser Company; describe the system in "Time Study Techniques for Logging Systems Analysis," a report published by the Intermountain Forest and Range Experiment Station.

The authors describe how standardized time study techniques can be used for analyzing the steps in a typical logging operation—mechanized felling, skidding with a rubber-tired tractor, and loading. They also include samples of the forms, flow process charts, and other materials necessary for a time and motion study.

For copies of the publication, General Technical Report INT-25-FR7, write the Intermountain Station, Ogden.

Thinning Douglas-fir

When do you precommercially thin Douglas-fir? How do you space the trees? These questions and others are answered in "Guidelines for Precommercial Thinning of Douglas-fir" by Donald L. Reukema. Reukema says that precommercial thinning is a practical means of substantially increasing wood production. His research has shown that stands should be thinned when crop trees are about 10 to 15 feet tall and 10 to 15 years old. At this age, Douglas-fir is generally advanced enough to show potential growth rate, stem and branching characteristics, and susceptibility to various types of damage. If thinning is delayed after competition begins, crop trees may never realize their full growth potential.

The number of trees left after precommercial thinning should depend upon the tree

size desired at the first commercial thinning. The report provides a guide to the desired number or spacing of trees, in terms of stand average d.b.h., number of trees, and basal area. Reukema warns that foresters should not maintain an overdense stand in one spot to offset a lack of trees in another. Also, foresters should strive for uniformity in tree size. As a general rule, it is best to remove all unwanted trees.

Reukema's paper, General Technical Report PNW-30-FR7, is available from the PNW Station, Portland.

Pollution from slash fires

Are EPA regulations about the smoke from slash fires bugging you? Do people complain about ash-covered laundry? If the answers are yes, you might want to get a copy of the publication, "Emissions from Slash Burning and the Influence of Flame Retardant Chemicals." The paper is based on the research of D. V. Sandberg and S. G. Pickford of the Pacific Northwest Station, and E. F. Darley of the University of California, Riverside.

First—the bad news. In tests conducted at UC Riverside, scientists applied the fire retardant DAP to fuel beds composed of ponderosa pine slash. They were interested in the distribution of the emissions of hydrocarbon gases, carbon dioxide, and total particulate matter during the course of the burning. Did DAP reduce pollution? According to the scientists, "The use of DAP to reduce the pollution potential was largely disappointing. This retardant increased all pollutants, especially the particulate faction, even though less fuel actually burned in treated fuel beds."

Now for the good news! Results indicated that the elimination of the fine fuels—those that constitute a wildfire risk—takes place during the initial stages of fire. Most gaseous emissions (potential pollutants) occur later, after the dangerous fine fuels have been consumed. Sandberg, Pickford, and Darley conclude that "Methods of burning which increase the proportion of high intensity burning or the rapid extinguishment of slash fires after burning the fine fuels should result in a pronounced decrease in amounts of gaseous pollutants."

Their report, which is a reprint from the *Journal of the Air Pollution Control Association* 25(3):278-281, is available from the Pacific Northwest Station, Portland.

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